TOWARDS MODELING OF RETROFIT PROCESSES

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Paul Szymkiewicz

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TOWARDS MODELING OF RETROFIT PROCESSES

Approved by:

Dr. Fried Augenbroe, Advisor
School of Architecture
Georgia Institute of Technology

Dr. Jason Brown
School of Architecture
Georgia Institute of Technology

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To my parents, you have opened the world to me.

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Most of all, no words will adequately express my gratefulness towards my family who has patiently supported me from day one. Thank you to my dear daughters who understood the frequently present-in-person but absent-in-mind dad, and finally my beloved wife Wei who encouraged me from day minus one.

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SUMMARY

Energy retrofits can be executed by a building owner with or without the supervision of a third-party agent. We define process models to capture third-party energy retrofit inspection activities, and refine, augment, and generalize those models to then examine the impact of third-party retrofit inspections. Buildings included in the study vary considerably in type, and so do retrofit programs applied to those buildings.

CHAPTER 1

INTRODUCTION

This work has been conducted with the support of Advanced Commercial Building Initiative program at Southface Energy Institute. ACBI brings DOE resources and combines local and regional energy efficiency programs with the goal of broadening adoption of energy efficiency packages for commercial buildings. Georgia Institute of Technology has joined the effort as a subcontractor providing analysis of third-party inspections and advice in new or retrofit projects. The goal of ACBI is to enable Southface and its partners to develop research-driven tools for meeting or exceeding 20% energy reduction for existing buildings and meeting Architecture 2030 target of 50% reduction for new construction.

It is assumed that projects which include energy savings guarantees in their financial models would be affected by a ranking of factors that cause discrepancy between actual and predicted energy performance in inspected and non-inspected buildings.

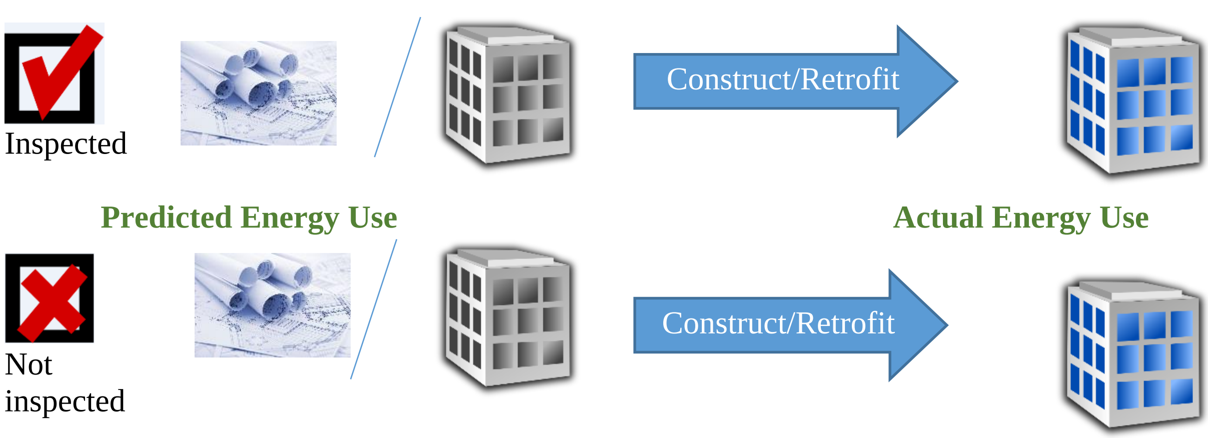

Figure 1.1: Inspected vs. non-inspected outcomes

Motivation

ACBI focuses on energy performance improvement, and thus we focus on this aspect alone, however, it needs to be noted that building performance is defined by more than energy alone: occupant comfort and health, durability, ease of use, and preservation of value for the building owner and occupant are all parts of performance definition.

Approach

There is a number of public/private agencies in the U.S. applying similar methods to that of Southface Energy Institute in bringing energy efficiency to commercial buildings. Since the scope of the project does not allow for a broader approach to retrofit/new construction inspection analysis, we focus solely on activities of Southface. If time and resources were available, expanding the scope to several players in the ESCO industry would potentially produce more reliable results.

The first object of this study is to find out what Southface does in their projects to influence the energy performance of buildings being investigated. Most importantly, the goal of this project is to model the activities "as is" and not as they should be. There is some danger of affecting the activities of Southface by the very questions being asked, as well as affecting the inspection or testing procedures by our presence and observations. We are going to hypothesize that while there are clear causal relationships between the actions of the intervening agent, Southface, and the resulting energy performance of a building, those actions may not always be selected and arranged in a way that optimizes the outcome, i.e. gives the best energy savings to cost ratio. To our knowledge, this relationship has not been formally studied in a new construction or retrofit environment, but only anecdotally supported by the common belief that inspections ought to improve the final product. The challenge here is to determine those third party causative factors on energy performance, and establish their magnitude, ultimately pointing to those activities in the entire process that have the most direct and largest impact. In basic terms, the main hypothesis is: if Southface is involved, on average the outcome is better.

The initial framework for this project is as follows:

1. We create work flow models with actors, activities, and triggers based on the BPMN 2.0 (Business Process Model and Notation) standard
2. We refine the models by collecting data from ongoing ACBI projects (this has been expanded to typical Southface projects within the various funding programs)
3. Next, we use the models to identify and classify levels of interactions offered by Southface
4. Assign an energy usage impact factor to each interaction type. Key: create a clear functional breakdown of activities according to measurable criteria
5. Select criteria quantifications for use in simulation with UA.

CHAPTER 2

PROCESS MODELS

Process models are a representation of what is happening and what types of interactions take place between the different actors. The slow by nature observe-and-capture research process of creating abstractions of actual human behavior has been motivated by curiosity about the effects of processes being modeled. Process model building is a mind-mapping activity, translating human behavior into a readable representation of process interdependencies. Process models are an intermediate goal: an elegant and easily communicable representation of processes. They are not meant to create an automated system for Southface.

Joy of modeling is driven by a clear purpose of having a model. Creating abstractions of human activities of energy efficiency inspection agents leads to identification of those interactions that ultimately affect the effectiveness of energy efficiency measures that are recommended and implemented. Process models have been created with the goal of isolating and describing those interactions.

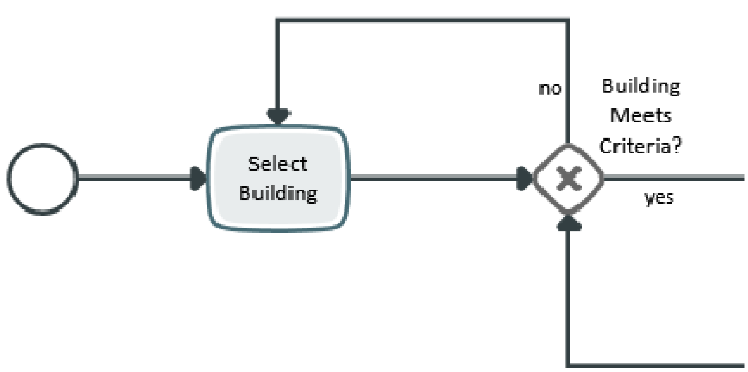

Figure 2.1: Over-generalized example of early process model flow.

What is clearly understood is that Southface is involved in giving design advice and performing inspections. What is difficult to capture is a representative snapshot or a model of both types of behavior that change over time and are dependent on the individual actor's version of execution.

Process models can be characterized as work in progress: as the human behavior changes over time, it becomes necessary to adjust the models. The observer's ability to capture that behavior also increases with time. An early model based on initial observations of Southface ACBI-related processes turned out to be a conglomerated model of different energy efficiency funding programs that Southface participates in. This model is an example of what an ACBI project collaboration could look like, however, it turned out to be an idealized model that does not match any of the individual programs Southface uses for introduction of energy efficiency measures. Feedback from this model prompted creation of program-specific process models that were based on thorough interviews and inspections of the different interactions, rather than observation alone.

The model in figure 2.2 has most of the elements of a BPMN process model such as swim lanes, which can be described as major activity tracks within the responsibility of each participant, sub-processes, start and end events, messages, message events, activities, gateways, and data. Example in figure 2.1 -- a snippet of the complete model in figure 2.2 -- shows the beginning part of the early process model flow. For example, this simple sequence of "Select Building" activity followed by an exclusive gate "Building Meets Criteria?" turned out to be too great a simplification for the Southface programs where this part occupies a much larger portion of the models.

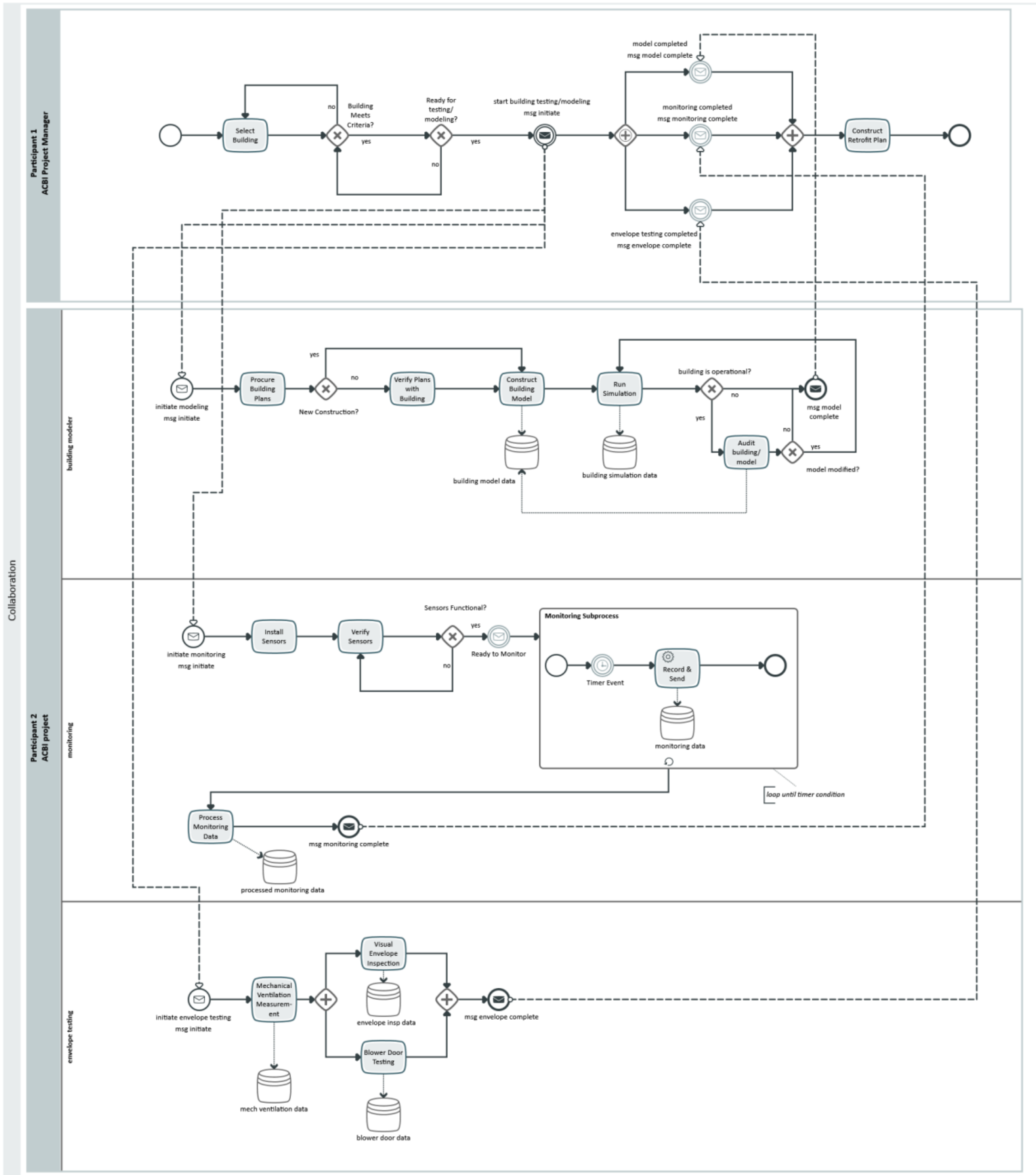

Figure 2.2: Early version of ACBI process model

We have grouped Southface projects into three categories for the purposes of process model building:

- ✓ ECLC (Earthcraft Light Commercial)
- ✓ G2G (Grants to Green)

✓ BGCA (Boys and Girls Clubs of America)

All three programs involve a third party agent, in this case Southface, whose overall task is to administer improvements in energy consumption of a building. In fact, all three programs include recommendations for environmental efficiencies beyond just energy, which includes water consumption, storm water management, traffic impact reduction, etc., however, for the purpose of this project we focus on energy consumption.

ECLC is the only new construction (or major renovation) program among the three. Comparable to other national programs, such as LEED, Green Globes, Energy Star etc., ECLC imposes a set of design and execution constraints on a building project through a point system. In general, buildings 15,000 ft^2 or less in gross floor area located in SE U.S. climate zones 2a, 3a, or 4a are admitted to the program. [xx]

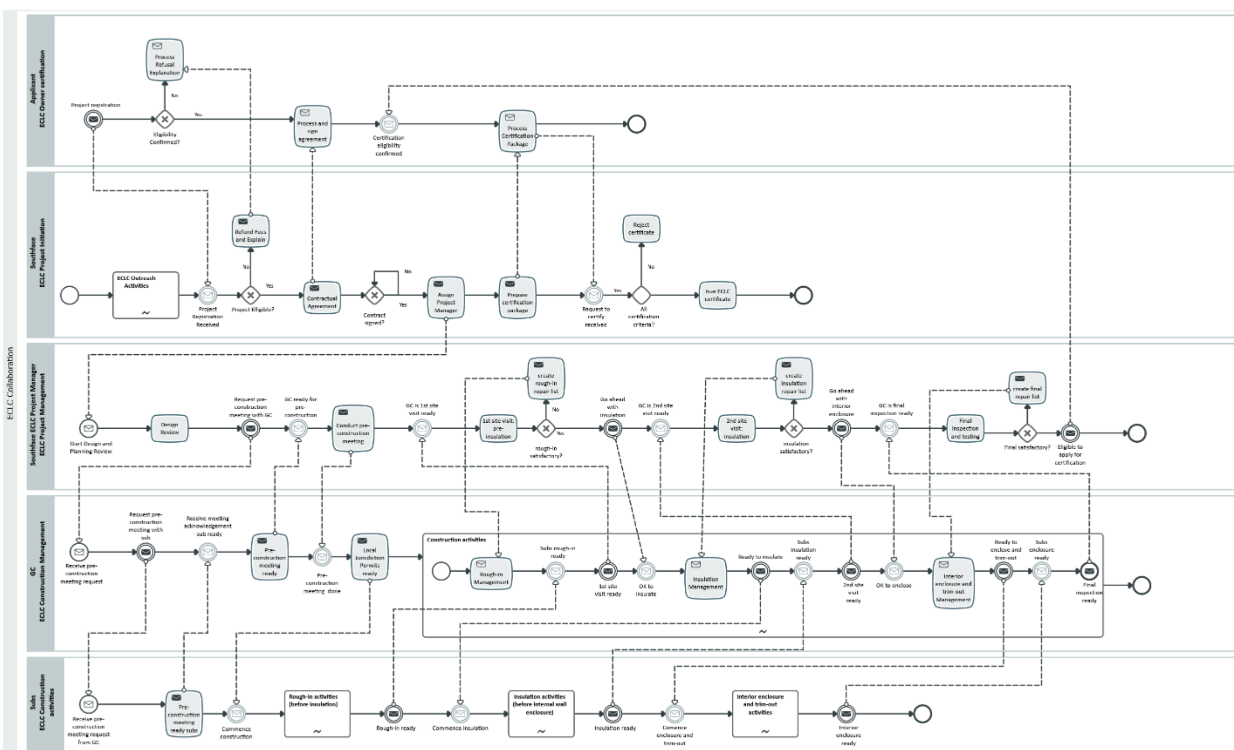

Figure 2.3: ECLC process model

G2G provides knowledge and funding to nonprofit organizations in the 23-county region around Atlanta to help them improve energy efficiency of their buildings. Nonprofits can receive two types of assistance: assessment awards – to help them with third party inspection costs, and implementation grants that enable installation of suggested improvements. [xx]

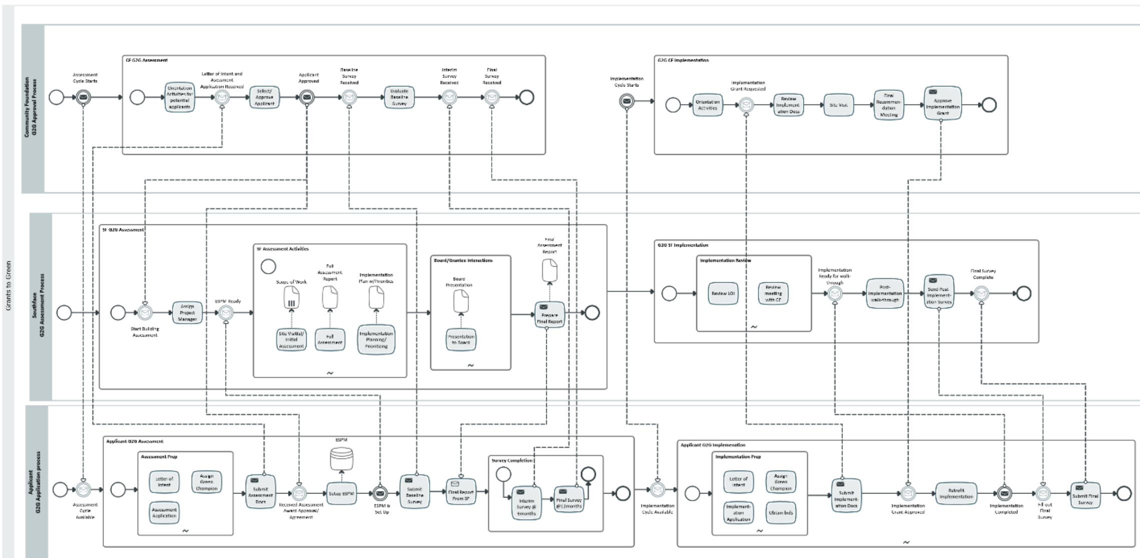

Figure 2.4: G2G process model

BGCA is an internally administered program by Southface and has a main goal of cutting club utility expenses by 20 percent, which includes energy and water, for clubs in the Southeast.

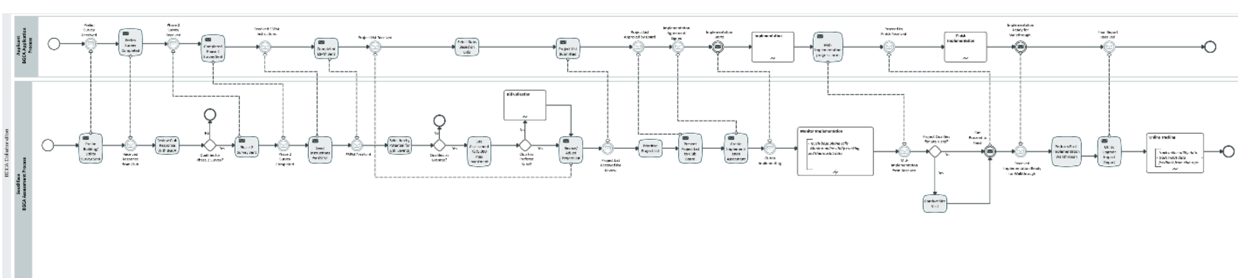

Figure 2.5: BGCA process model

All three Southface programs can in very general terms be reduced to a simple process model as shown in figure 2.6.

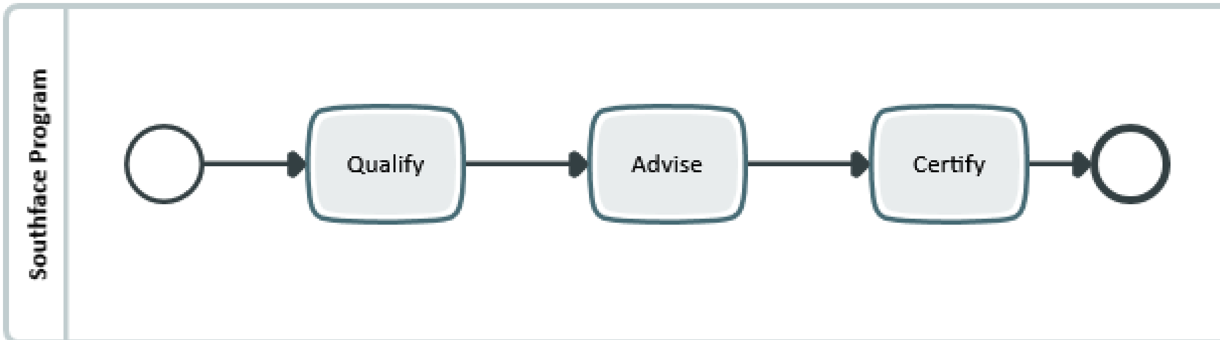

Figure 2.6: Condensed process model

In order to more precisely capture the different types of interventions Southface makes in these three programs and the context in which those interventions are made, much more detailed and specific process models are necessary.

Southface interventions fall into two categories: design advice and inspections. Design advice is relevant to new construction projects, as is the case with ECLC, and retrofit projects, as is the case with G2G and BGCA. Inspections are relevant to both types of programs in varying degrees.

CHAPTER 3

DESIGN ADVICE ASSESSMENT

We put design advice into two categories: (1) design of new buildings, and (2) specification of retrofit measures of existing buildings. In this chapter we are going to examine what building parameters are affected by SF advice, and in general how are those building parameters correlated to the outcome, i.e. energy performance. We then perform thousands of normative energy simulations (EPC) to obtain more reliable results that are grouped and analyzed with the help of ModelCenter's probabilistic analysis module. The result of this analysis is a ranking of the correlations between building parameters and energy performance which is intended here to form a template against which SF design advice can be measured.

Simply put, we ask these two basic questions:

1. Which design measures give us highest improvement in energy performance in a given climate?
2. For which building types, what measures have most impact?

Setting up the Experiments

This type of study can easily expand into an enormous number of permutations of building types, design measures, and climates. We take a narrow snapshot and focus on Atlanta, GA climate (mixed humid), and a basic building type generally representative of ACBI set: a variant of small office building out of the U.S. Department of Energy reference buildings set:

(a) Single level, 511 m^2 (5500 ft^2), urban setting, light construction, rectangular building with and aspect ratio of 1.5 between East/West and North/South.

We then identify the following building parameters as input variables in the probabilistic analysis:

Table 3.1: Input variable ranges

Input variable	**Value Range**	**Units**
Appliance loads	4 ... 22	W/m^2
Lighting loads	7 ... 14	W/m^2
Glass U value (SI)	1 … 6	W/m^2K
Wall U value (SI)	0.3 … 0.6	W/m^2K
Roof U value (SI)	0.2 … 0.6	W/m^2K
Infiltration	0.45 … 5.35	m^3/h per m^2 at Q4Pa[1]
Glass Solar Transmittance	0.1 … 0.8	
Window ratio	0.2 ... 0.6	
Cooling set point	23.5 … 25	˚C

In reality, most of the above value ranges are discrete sets, however, to simplify running of the probabilistic analysis module, we define them all as uniformly distributed. The above set serves both new construction and retrofit analysis, with the exception of *window ratio* which is removed from the retrofit set.

Output is energy demand of the building, i.e. energy needed to satisfy thermal set points without considering energy consumed to run HVAC equipment, produce hot water, or run pumps and fans. Because of the uniqueness of Atlanta climate zone (3a), we separate cooling need and heating need from the total and thus create three output variables (response):

[1] This range is equivalent to 0.05 … 0.62 ACH (at Q4Pa) for the example building.

Table 3.2: Output variables

Output variables	**Units**
Energy need	kWh/m^2 per year
Cooling need	kWh/m^2 per year
Heating need	kWh/m^2 per year

Remaining building parameters affecting energy demand are fixed:

Table 3.3: Fixed parameters

Fixed parameters	**Value**	**Units**
Building height	3.1	M
Total ventilated volume	1584	m^3
Roof emissivity	0.7	
Roof absorptivity	0.8	
Occupancy	14.29	m^2/person
Metabolic rate	120	W/person
Outdoor air supply	10	liter/s/person
Schedules	office	
Lighting controls	none	

Results: Retrofit Set

For the retrofit set (input variables with window ratio removed), four series of experiments were run with increasing number of EPC simulator runs, each with a random permutation of inputs: 1000, 5000, 10000, and 15000 using the Monte Carlo sampling technique. The seed for the random number generator was not saved between the runs in order not to replicate results between the series. Consistency of the main objective of the experiments - input variable sensitivities – was verified by the increasing number of runs, or samples as can be seen in the figure 3.1 below.

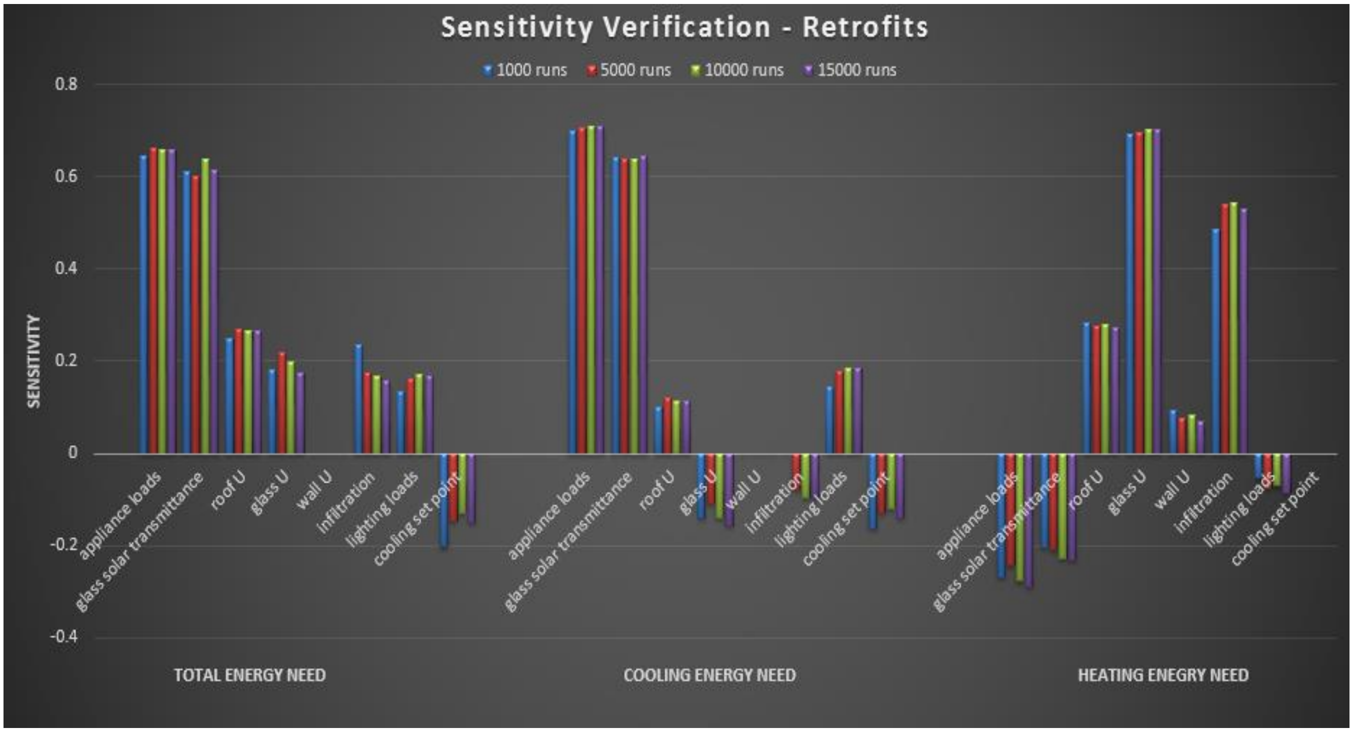

Figure 3.1: Verification of sensitivity experiments for retrofit set

It is safe to say that the sensitivities of input variables were consistent with increasing number of runs or samples. Details of the 15,000 runs series are in figure 3.2 below and show that overall energy need and cooling energy need were both closely correlated to appliance loads and solar transmittance of glazing, while heating energy need alone was closely correlated to glazing u-value and building infiltration. Atlanta's climate, however, "made" those heating energy need correlations become much less significant among the overall energy need sensitivities.

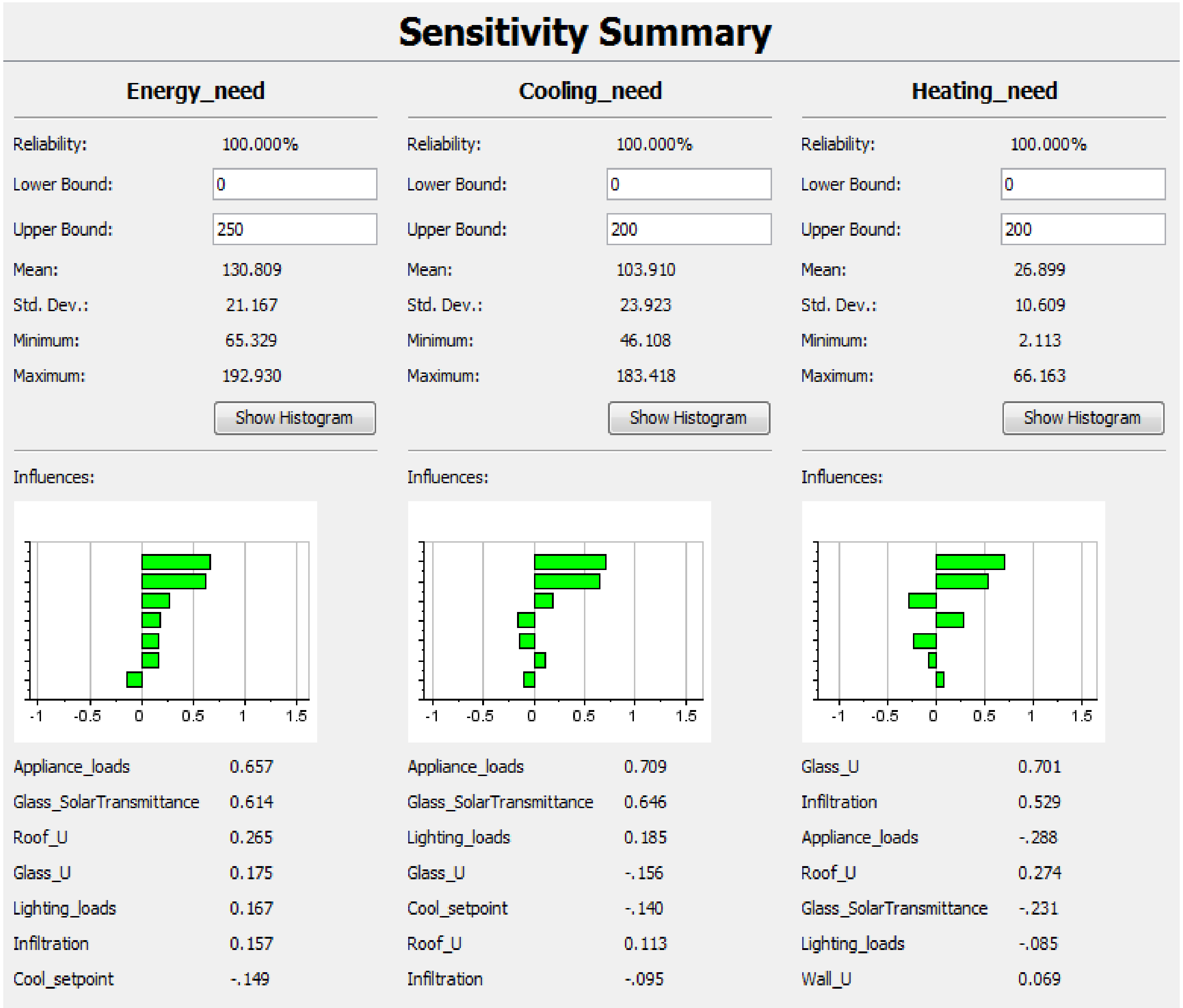

Figure 3.2: Sensitivity summary for retrofit set

The lack of stronger correlation between infiltration and cooling energy need may be related to the absence of interior RH input setting in the normative EPC calculator. Much higher heating season ΔT_{AIR} between indoor and outdoor space is contributing to high sensitivity of infiltration during heating months.

Figure 3.3 below illustrates the dominant cooling energy need sensitivities: appliance loads (x-axis) and solar transmittance of glazing (dot color scale).

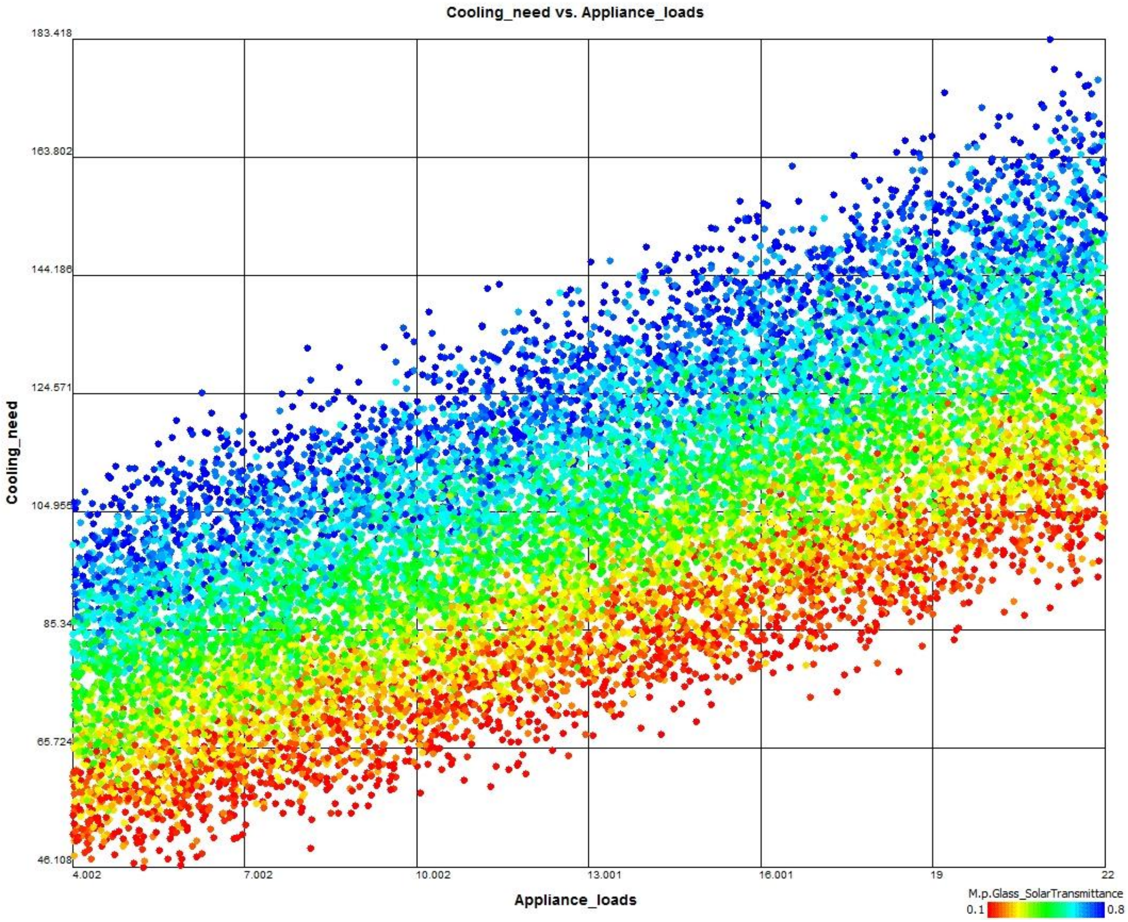

Figure 3.3: Cooling energy need vs. appliance loads with glazing solar transmittance

Results: New Construction Set

For the new construction set (input variables now include window to wall ratio), similarly to retrofit set, four series of experiments were run with increasing number of EPC simulations: 1000, 5000, 10000, and 15000 using the Monte Carlo sampling technique. Consistency of the main objective of the experiments - input variable sensitivities – was verified as can be seen in the figure 3.4 below.

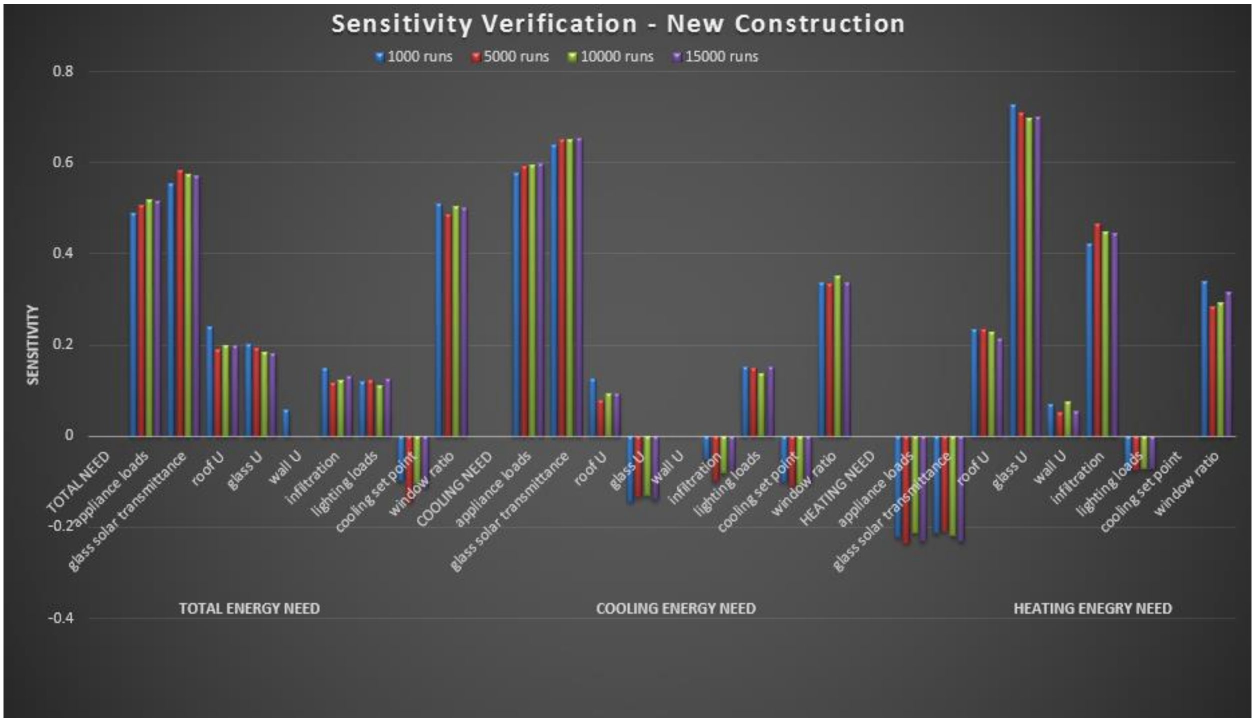

Figure 3.4: Verification of sensitivity experiments for new construction set

It is safe to say that again the sensitivities of input variables were consistent with increasing number of runs for the new construction set. Details of the 15,000 run series are below and show that overall energy need and cooling energy need were both closely correlated to appliance loads, solar transmittance of glazing, and window to wall ratio, while heating energy need alone was closely correlated to glazing u-value, building infiltration, and window to wall ratio. Again, among the overall energy need sensitivities, glazing u-value and infiltration are subdued and the only sensitivity that has a strong presence in all three output groups is window to wall ratio.

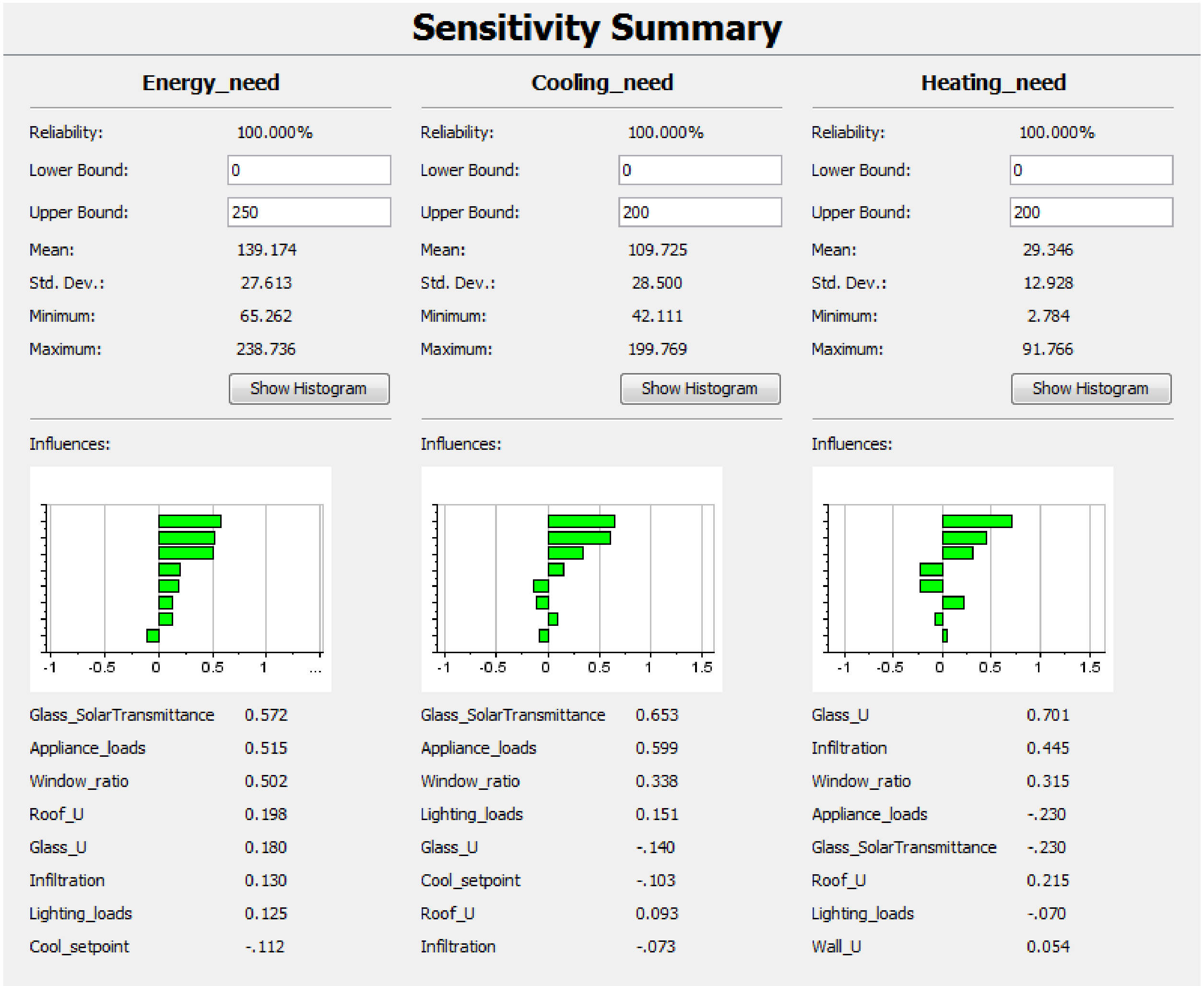

Figure 3.5: Sensitivity summary for new construction set.

Window to wall ratio, once introduced to the new construction input set, takes a strong presence among the top three input variable sensitivities in all categories: heating, cooling, and total energy need. It is interesting to note that, once again, infiltration is very weakly correlated to cooling energy need, and cooling set point does not play a strong role (we do acknowledge that the selected range for cooling set point range is modest: 23.5 – 25 ˚C).

The 3D graph in figure 3.6 below illustrates the dominant cooling energy need sensitivities: solar transmittance of glazing, appliance loads, and window to wall ratio, with cooling energy need being represented by dot color scale.

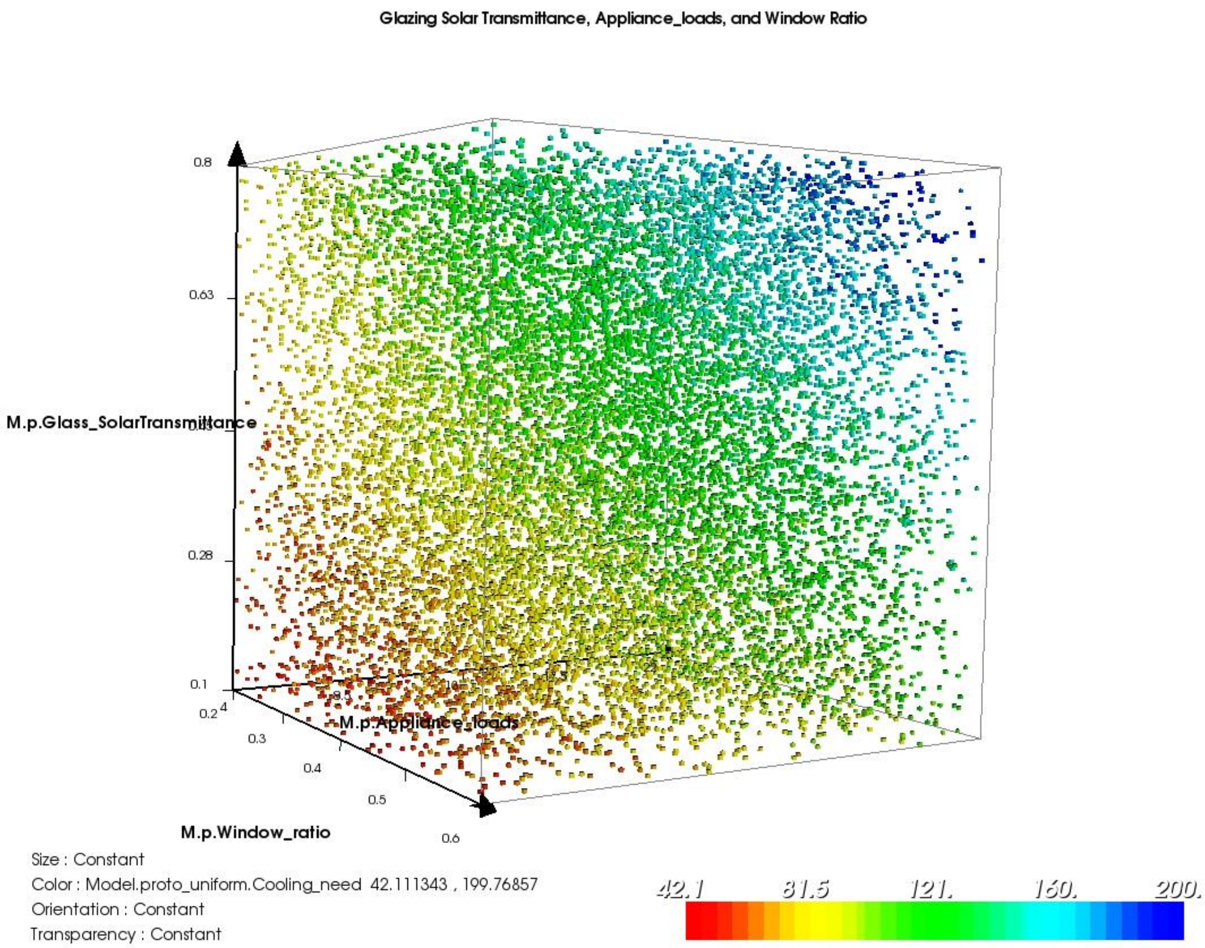

Figure 3.6: Dominant cooling energy need sensitivities

Results as Templates

The following is a methodology towards using the theoretical results of probability analysis presented in this chapter to categorize actual inspection methods. We take real consultancy reports – see examples in Appendix C - analyze them, and score them on a normative effectiveness scale. For each Southface interaction: do we see a new kind? Do we find enough similarity among projects? Later, we may repeat the procedure implemented in chapter 3 for each real building, while still adjusting the methodology and sensitivity testing prototypes; also, one would ideally add cost to ECM's to arrive at energy savings per $ invested. (Improve on PNNL ECM simulations: "Development and Implementation of a Parametric Energy Tool for Building Owners"). Finally, we would consider climate and occupancy variability in the sensitivity testing.

Another consideration would be creating varying levels of accomplishment for ECM sets, based on client preference or financing ability.

Last but not least, bringing any new or retrofit project to completion and finally occupancy, we look at any gaps between design and implementation remembering that advice is preconditioned on the fact that recommendations will be implemented correctly.

CHAPTER 4

INSPECTION ANALYSIS

In this chapter, we identify from process models the types of inspections performed as well as identify inspection parameters or building properties affected by the inspection services. Relating those building properties to particular inspection services sets up a framework for the uncertainty quantification analysis that will help make conclusions about the effectiveness of each inspection type in the absence of a sufficiently large set of inspected buildings.

We assign the following types of inspections:

- *design review:* plans and specifications are reviewed and advised, or in the case of retrofits - current conditions are reviewed and improvements advised
- *workmanship review:* field implementation of affected building features is scrutinized for errors
- *performance testing:* building envelope tightness is tested and major leakage points identified
- *performance projections:* given certain improvements, reductions in energy use are suggested
- *calibration:* existing building actual performance (delivered energy) is tabulated based on usage data

The type of inspection performed is equivalent to the resulting communication about its findings. Without the communication it is very difficult or impossible to identify the parameters that were inspected. We have found the following major types of communication taking place in the three main programs studied (assigned type of inspection is in square brackets):

For ECLC:

- design review feedback notes [*design review*]
- pre-construction meeting minutes [*design review*]
- repair lists sent back at each: pre-insulation, insulation [*workmanship review*]
- final results (blower door testing) [*performance testing*]

For G2G:

- initial assessment, site visit notes + scope of work [*design review*]
- full assessment, audit report [*design review*]
- client board presentation notes/slides [*performance projections*]
- final report [*performance projections*]
- post-implementation walk-through notes [*workmanship review*]

For BGCA:

- completed and selected ESPM's (Energy Star Portfolio Manager) [*calibration*]
- site assessment notes [*design review*]
- recommended project list sent to client board [*performance projections*]
- mid-implementation site visit notes [*workmanship review*]
- post-implementation walk through notes [*workmanship review*]

Further, undocumented interactions:

- comments during inspections
- phone conversations
- Southface interactions with GC/subs

Coming back to the prototype input variables from chapter 3: appliance loads, lighting loads, glass u-value, wall u-value, roof u-value, infiltration rate, glass solar transmittance, window to wall ratio, and cooling set point, we attempt to match these variables with types of inspection activities that affect them. This rather arbitrary process, since inspections can be quite subjective and incomplete, yields the following mapping:

[d*esign review*] → all except *cooling set point*

[*workmanship review*] → wall u-value, roof u-value, infiltration rate

[*performance projections*] → appliance loads, lighting loads

[*calibration*] → appliance loads, lighting loads, cooling set point

[*performance testing*] → infiltration rate

Goal of next phase of this research is measuring the impact of each Southface intervention in terms of resulting energy performance. This step will include: simulation, calibration against measured consumption, and statistical analysis.

For example, one could try to establish whether a Southface inspection guarantees a decrease in the resulting leakiness of the building envelope, or ELR: Envelope Leakage Ratio defined by Southface as CFM50/SFBE, where SFBE is square footage of building envelope. This could be translated in a test of the following form,

$$P(ELR_{insp} < ELR_{no\_insp}) \geqq 90\% \ ?$$

meaning "is the probability that the leakage ratio decreases if Southface is involved in an inspection greater than 90%?"

The next phase of this research will set up the data analysis procedures to execute these tests and establish the confidence interval for them.

CHAPTER 5

CONCLUSIONS

This thesis lays out an important ground work of building models of ECM inspection activities of third-party agents who are generally hired by the owner of the project to act as a supervisor and advocate for energy efficiency of the building to be built or retrofitted. This work could be extended by taking a deeper look at ESCO services in general, beyond just the procedures of Southface.

Further analysis is needed to rank options to be executed to meet or exceed performance, or in other words what could Southface do towards a guarantee of savings? Where are the projected savings in the Southface process models? More work is needed to identify those savings it and detail the processes. Moreover, would the projecting itself have any influence on final performance? What would be some emerging building properties that affect outcome?

Finally, the only way to compare Southface services is against other ESCO's and this is risky – one would have to compare to a whole spectrum of auditors. We would need to keep in mind that analysis of utility of Southface work is not the goal of this project.

APPENDIX A

PROCESS MODELS

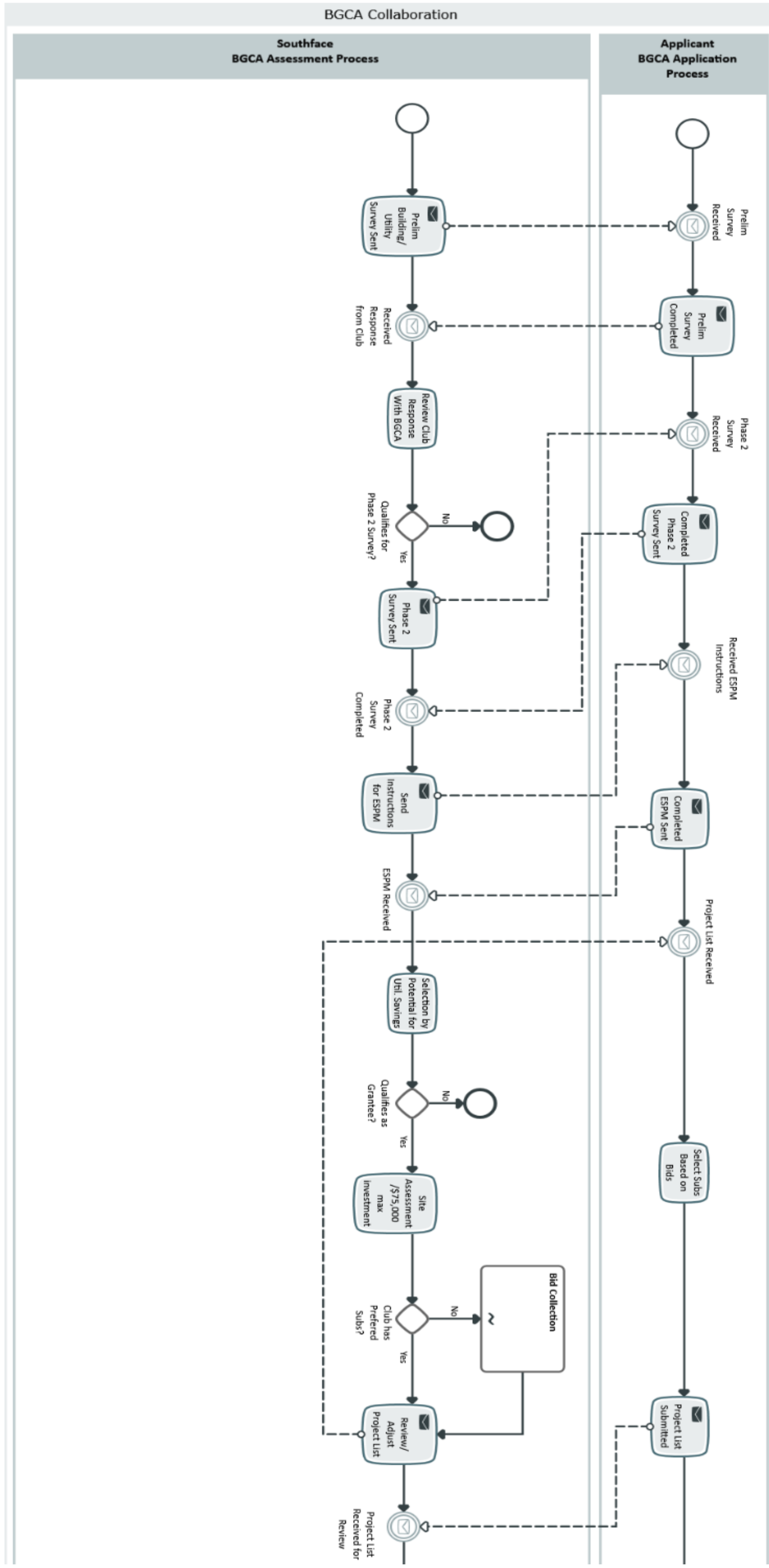

Figure A.1: BGCA process model (left part)

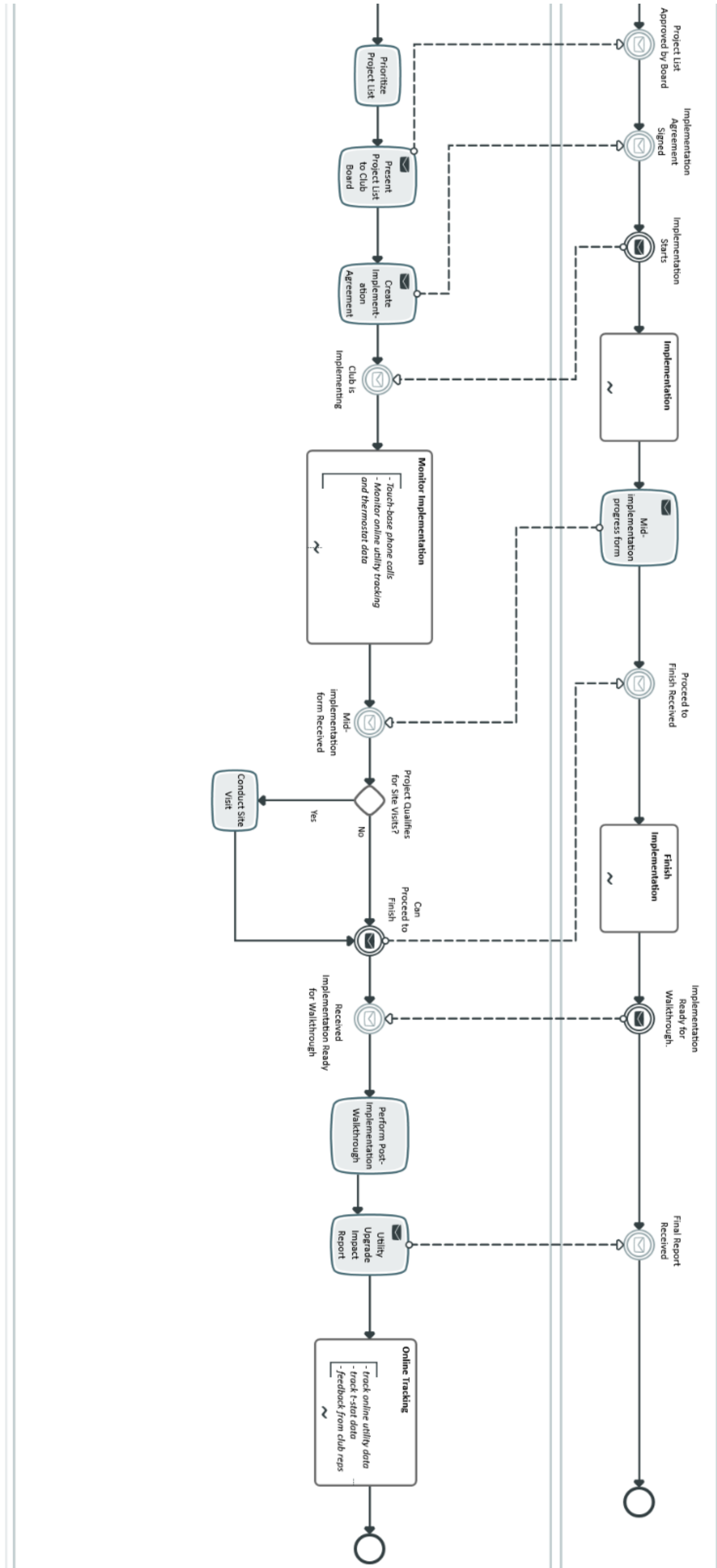

Figure A.2: BGCA process model (right part)

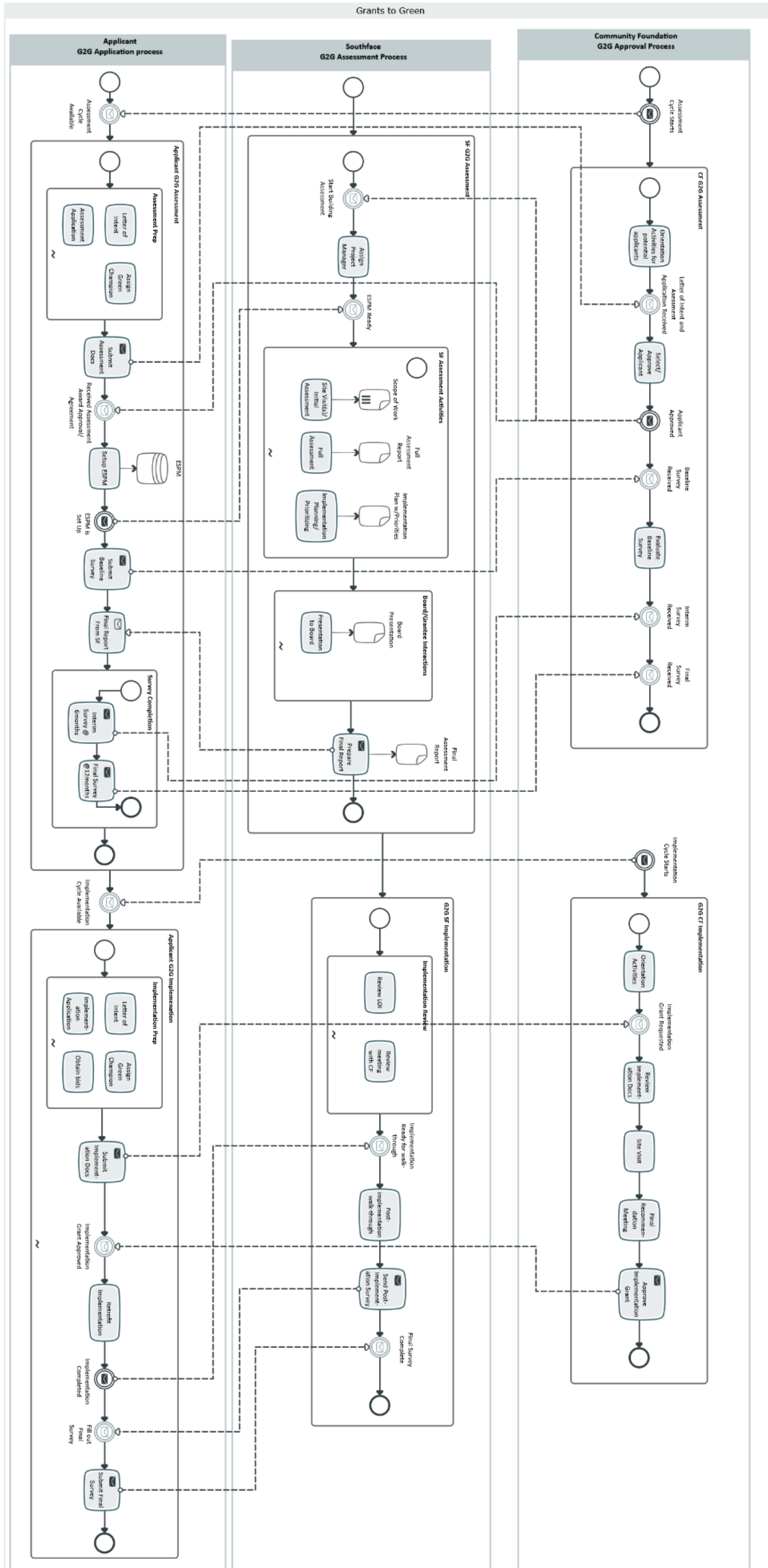

Figure A.3: Grants to Green process model

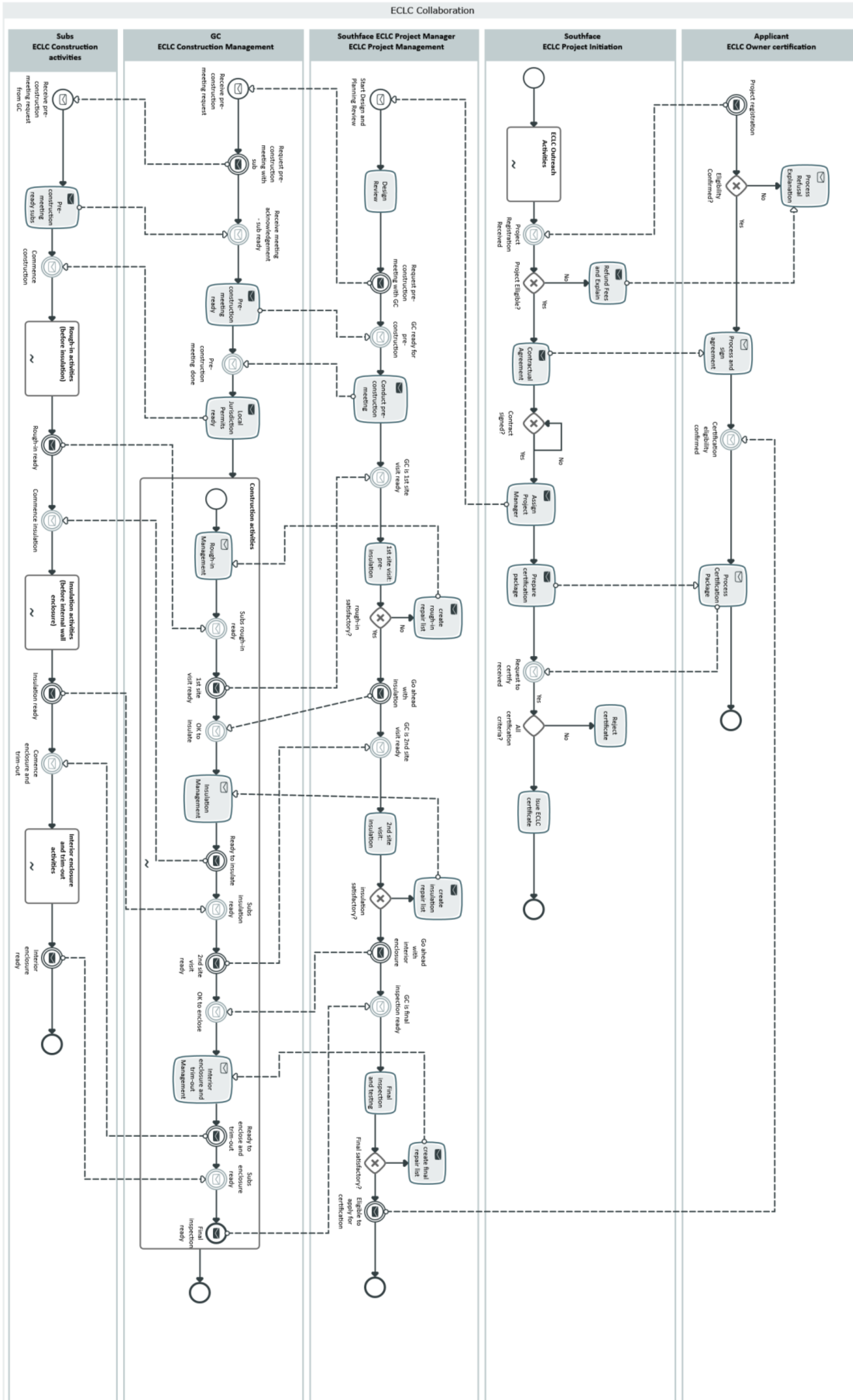

Figure A.4: Earthcraft Light Commercial Process Model

APPENDIX B

SENSITIVITY STUDY

Table B.1: Input variables - retrofit set

# of runs (samples):	**1,000**	**5,000**	**10,000**	**15,000**
total need mean	129.035	130.832	130.363	130.809
cooling need mean	101.656	104.072	103.281	103.91
heating need mean	27.38	26.76	27.082	26.899
				[kWh/m2]
Total need	**Sensitivities:**			
appliance loads	0.644	0.661	0.658	0.657
glass solar transmittance	0.61	0.602	0.639	0.614
roof U	0.249	0.268	0.267	0.265
glass U	0.18	0.218	0.198	0.175
wall U	0	0	0	0
infiltration	0.236	0.175	0.166	0.157
lighting loads	0.133	0.162	0.171	0.167
cooling set point	-0.203	-0.146	-0.129	-0.149
Cooling need				
appliance loads	0.7	0.705	0.71	0.709
glass solar transmittance	0.641	0.637	0.639	0.646
roof U	0.101	0.121	0.112	0.113
glass U	-0.14	-0.109	-0.139	-0.156
wall U	0	0	0	0
infiltration	0	-0.079	-0.096	-0.095
lighting loads	0.144	0.179	0.184	0.185
cooling set point	-0.164	-0.13	-0.119	-0.14
Heating need				
appliance loads	-0.269	-0.242	-0.276	-0.288
glass solar transmittance	-0.204	-0.209	-0.227	-0.231
roof U	0.284	0.276	0.279	0.274
glass U	0.693	0.696	0.701	0.701
wall U	0.093	0.077	0.083	0.069
infiltration	0.485	0.541	0.542	0.529
lighting loads	-0.054	-0.075	-0.071	-0.085
cooling set point	0	0	0	0

Table B.2: Input variables - new construction set

# of runs (samples):	1,000	5,000	10,000	15,000
total need mean	138.92	138.756	139.299	139.174
cooling need mean	109.348	109.327	109.856	109.725
heating need mean	29.572	29.289	29.329	29.346
				[kWh/m2]
Total need	**Sensitivities:**			
appliance loads	0.489	0.506	0.518	0.515
glass solar transmittance	0.554	0.582	0.575	0.572
roof U	0.24	0.19	0.2	0.198
glass U	0.201	0.193	0.183	0.18
wall U	0.058	0	0	0
infiltration	0.149	0.116	0.124	0.13
lighting loads	0.12	0.122	0.11	0.125
cooling set point	-0.099	-0.144	-0.103	-0.112
window ratio	0.509	0.488	0.505	0.502
Cooling need				
appliance loads	0.579	0.591	0.594	0.599
glass solar transmittance	0.638	0.652	0.651	0.653
roof U	0.125	0.078	0.093	0.093
glass U	-0.144	-0.134	-0.131	-0.14
wall U	0	0	0	0
infiltration	-0.052	-0.099	-0.08	-0.073
lighting loads	0.152	0.149	0.136	0.151
cooling set point	-0.1	-0.108	-0.105	-0.103
window ratio	0.336	0.333	0.352	0.338
Heating need				
appliance loads	-0.222	-0.235	-0.212	-0.23
glass solar transmittance	-0.213	-0.209	-0.219	-0.23
roof U	0.233	0.233	0.229	0.215
glass U	0.727	0.71	0.697	0.701
wall U	0.071	0.051	0.075	0.054
infiltration	0.422	0.466	0.449	0.445
lighting loads	-0.076	-0.073	-0.071	-0.07
cooling set point	0	0	0	0
window ratio	0.341	0.284	0.293	0.315

Energy need distribution as a result of EPC model uncertainty experiments.

(Each bar represents 100 samples, or runs)

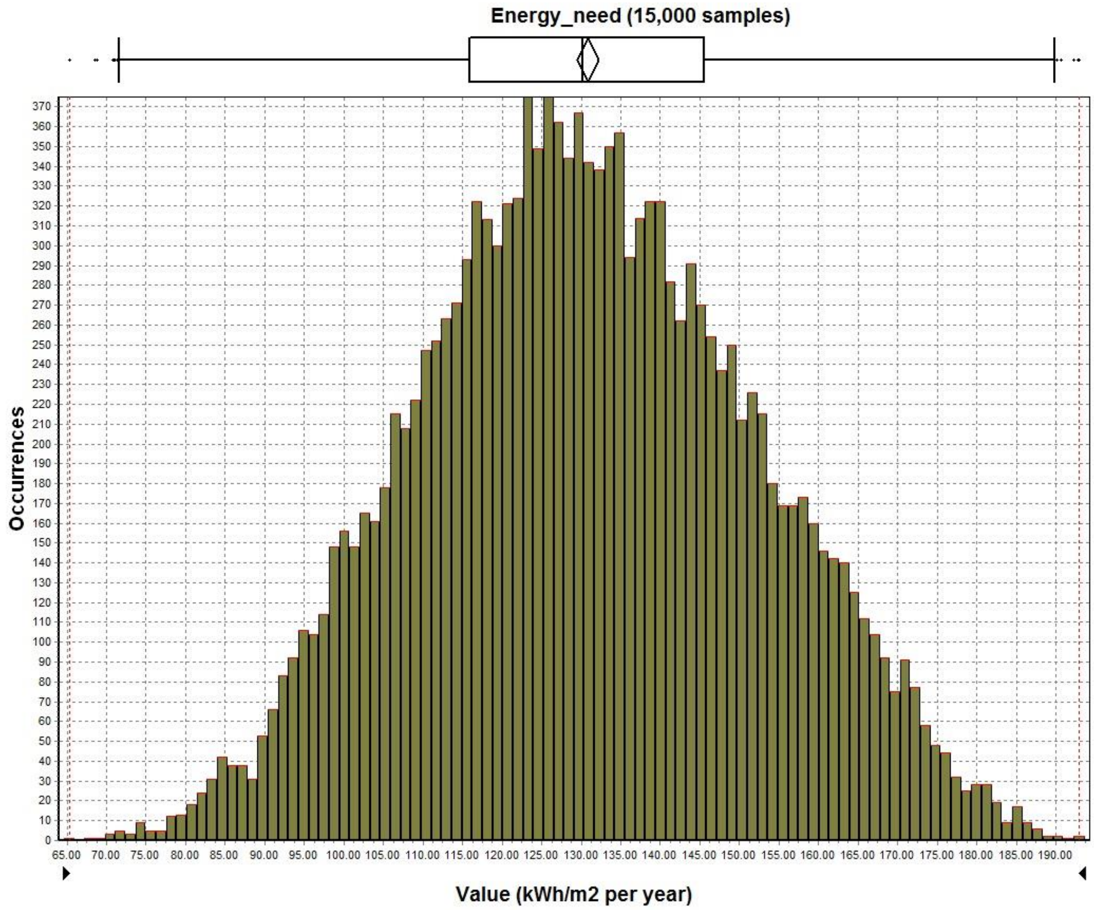

Figure B.1: Total energy need, retrofit set

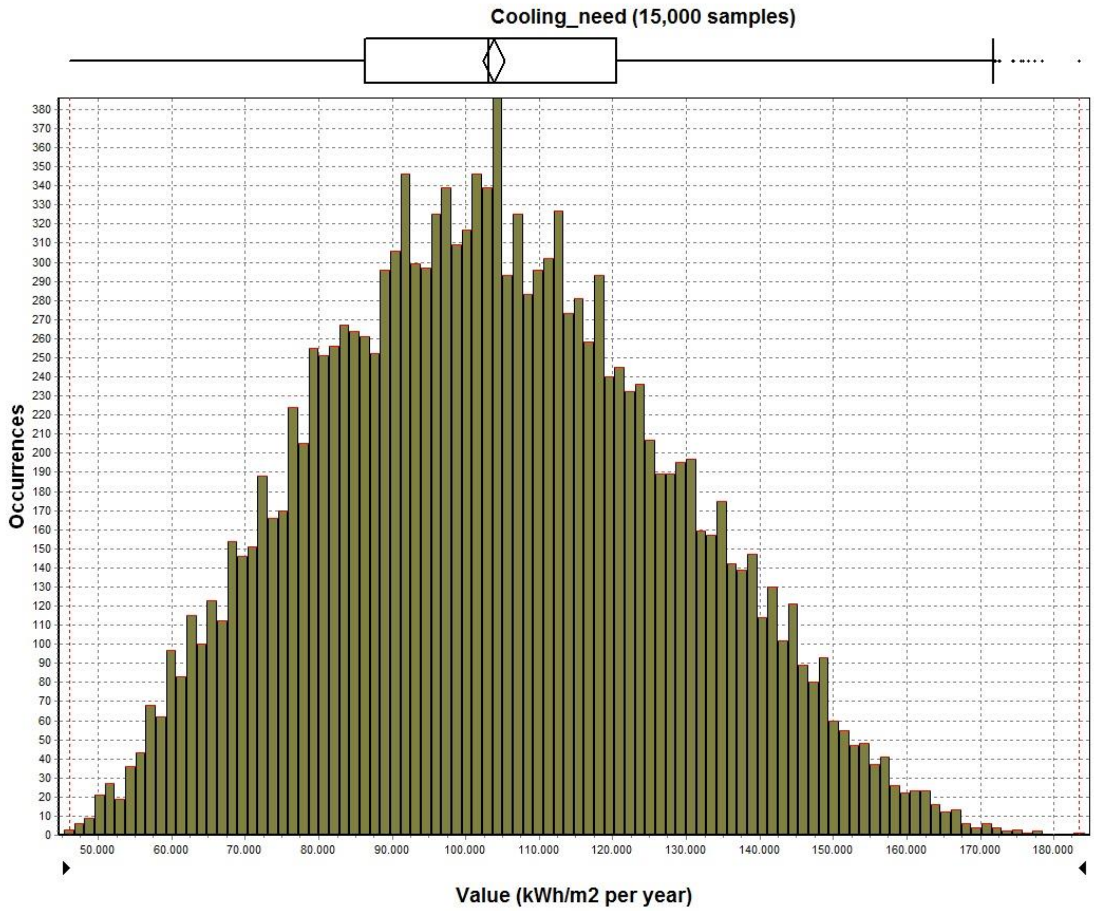

Figure B.2: Cooling energy need, retrofit set

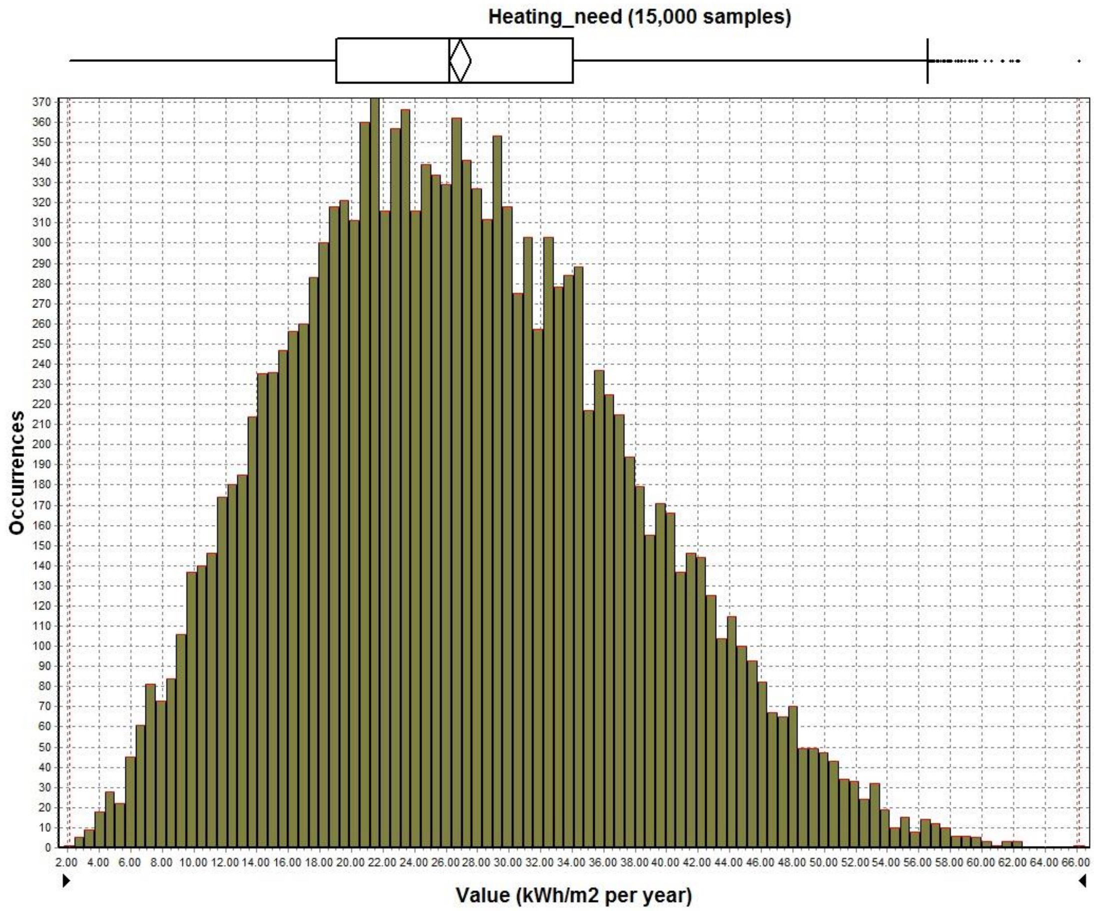

Figure B.3: Heating energy need, retrofit set

APPENDIX C

ECM ADVICE

Table C.1 shows examples of actual retrofit design advice (energy conservation measures; listed water conservation measures were preserved for completeness).

Table C.1: Actual retrofit design advice

Project Type/name:	Recommendations	Allocated cost	Projected Annual Utility savings
BGC building 8,480 sq. ft.	Replace T8 fluorecent tube lighting with T8 LED tubes. Install occupancy-based lighting controls, and photocell control on exterior canopy lighting. (13 wall sensors, 4 ceiling sensors, & 1 photocell for canopy - equipment & installation) $5,796 for 252 Philips 14.5W T8 LED tubes; and a $500 contingency to cover defective ballasts, etc.	$ 8,634.00	$ 1,000.00
	Install web-enabled programmable thermostats (Entouch Controls)	$ 1,750.00	
	Replace refrigerant line insulation with reflective insulation.	$ 1,350.00	
	Install threshold at conference room door.	$ 200.00	
	Replace 2 urinals with pint-flush. Replace aerators with 0.5-GPM units (aerators already provided).	$ 1,225.00	

Table C.1 continued

<table>
<tr><td rowspan="10">BGC building #2</td><td>Replace (16) existing 3+ GPF Water closets with 1.28 GPF. Replace (5) 1.0 GPF urinals With pint-flush.</td><td>$ 13,165.00</td><td rowspan="10">not reported</td></tr>
<tr><td>Upgrade insulation from R13 To R19.</td><td>$ 3,097.00</td></tr>
<tr><td>Install reflective window film to 640 sq.ft. of windows.</td><td>$ 1,720.00</td></tr>
<tr><td>Set up recycling program; Includes recycling stations.</td><td>$ 1,750.00</td></tr>
<tr><td>Install vending misers to control Snack & drink machines based on occupancy.</td><td>$ 733.00</td></tr>
<tr><td>Weatherize gym by sealing Intake & exhaust louvers and adding thresholds.</td><td>$ 2,000.00</td></tr>
<tr><td>Install 16 wireless web--- based occupancy--- sensing thermostats.</td><td></td></tr>
<tr><td>replace 8 through-wall heat pumps (3-ton each)</td><td>$ 67,810.00</td></tr>
<tr><td>Install LED Lighting & Controls.</td><td>$ 33,793.00</td></tr>
<tr><td>Apply reflective coating to gymnasium roof</td><td>$ 28,598.00</td></tr>
<tr><td rowspan="7">BGC building
22600 sq.ft.
76 kBtu/sq.ft. (existing)</td><td>Install selected high-performance LED lighting and controls.</td><td>$ 44,214.00</td><td rowspan="7">$ 12,040.00</td></tr>
<tr><td>Convert to seasonal gas rate</td><td>$ -</td></tr>
<tr><td>Replace refrigerator with Energy Star model.</td><td>$ 997.00</td></tr>
<tr><td>Upgrade building automation system.</td><td>$ 26,350.00</td></tr>
<tr><td>Install vending misers to control snack & drink machines.</td><td>$ 750.00</td></tr>
<tr><td>Install rainwater harvesting system.</td><td>$ 1,800.00</td></tr>
<tr><td>Replace standard plumbing fixtures with low-flow.</td><td>$ 4,625.00</td></tr>
</table>

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